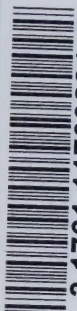
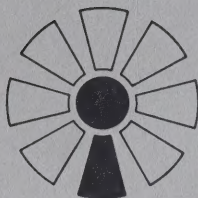


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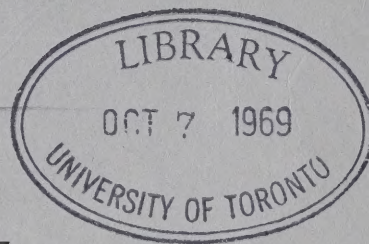


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**STATISTICAL DATA ON
INDUSTRIAL RESEARCH
AND
DEVELOPMENT IN CANADA**



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PRESENTED BY

J.L. ORR

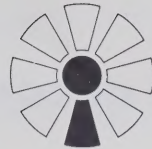
**INDUSTRIAL RESEARCH ADVISER
DEPARTMENT OF INDUSTRY, OTTAWA
TO THE
SCIENCE COUNCIL OF CANADA**

MARCH 17, 1967



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**STATISTICAL DATA ON
INDUSTRIAL RESEARCH
AND
DEVELOPMENT IN CANADA**

**PRESENTED BY
J.L. ORR
INDUSTRIAL RESEARCH ADVISER
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INTRODUCTION

The tables, charts and commentaries reproduced herein were presented as part of a report on Industrial Research and Development in Canada to the Science Council of Canada at its meeting on March 17, 1967 by Mr. J.L. Orr, Industrial Research Adviser, Department of Industry.

The material was prepared by Mr. H.C. Douglas and Mr. M. Eliesen of the Department of Industry. The assistance of the Dominion Bureau of Statistics and in particular of Mr. H. Stead, Chief of the Scientific Activities Surveys Section, who made available preliminary results of the Bureau's survey of industrial research and development expenditures in Canada in 1965 and other unpublished data, is gratefully acknowledged.

Office of Industrial Research Adviser
Department of Industry

Table 1 and Chart 1

Gross National Expenditures (current and capital) on Research & Development as a Percentage of Gross National Product (at current market price) and Per Capita G.N.P. in U.S. Dollars (at official exchange rates), for a number of countries.

Sources

- (a) For all countries except Canada: O.E.C.D., *Statistical Tables and Notes, International Statistical Year on Research and Development*, O.E.C.D. Document DAS/SPR/66.14, Paris, 23 January 1967.
- (b) For Canada: D.B.S.; and APPENDIX, Table C.

Commentary

Many studies and analyses have been made in an attempt to establish the relationship between the research and development expenditures by a country and its economic health. Most of them have been inconclusive, as Chart 1 shows.

As may be seen, the United States spends more on R & D than any other country and also has the highest per capita Gross National Product. On the other hand, Canada which spends a smaller proportion of its G.N.P. on R & D than the United Kingdom, the Netherlands, Japan, France, Germany or Sweden, enjoys a per capita G.N.P. second only to the United States. (This may be a reflection of Canada's effective use of imported technology). Moreover, the per capita G.N.P. of Japan is less than that of Belgium, Norway, Italy, Ireland or Austria, although it spends relatively more on R & D. Despite these inconsistencies, it will be noted that there is a positive correlation between these factors.

Table 1

Gross National Expenditures on Research & Development as a Percentage of G.N.P., and Per Capita G.N.P. in U.S. Dollars

COUNTRY	YEAR	R&D EX- PENDITURES % G.N.P.	PER CAPITA G.N.P. \$ U.S.
United States	1963/64	3.4	3243
United Kingdom	1964	2.3	1700
Netherlands	1964	1.9	1385
France	1963	1.6	1674
Japan	1963	1.5	622
Sweden	1964	1.5	2281
Germany	1964	1.4	1774
Canada	1965	1.3	2431
Belgium	1963	0.9	1502
Norway	1963	0.8	1537
Italy	1963	0.6	897
Ireland	1963	0.5	805
Austria	1964	0.3	1172

Chart 1

Gross National Expenditures on Research & Development
as a Percentage of G.N.P. v. Per Capita G.N.P. in U.S. Dollars

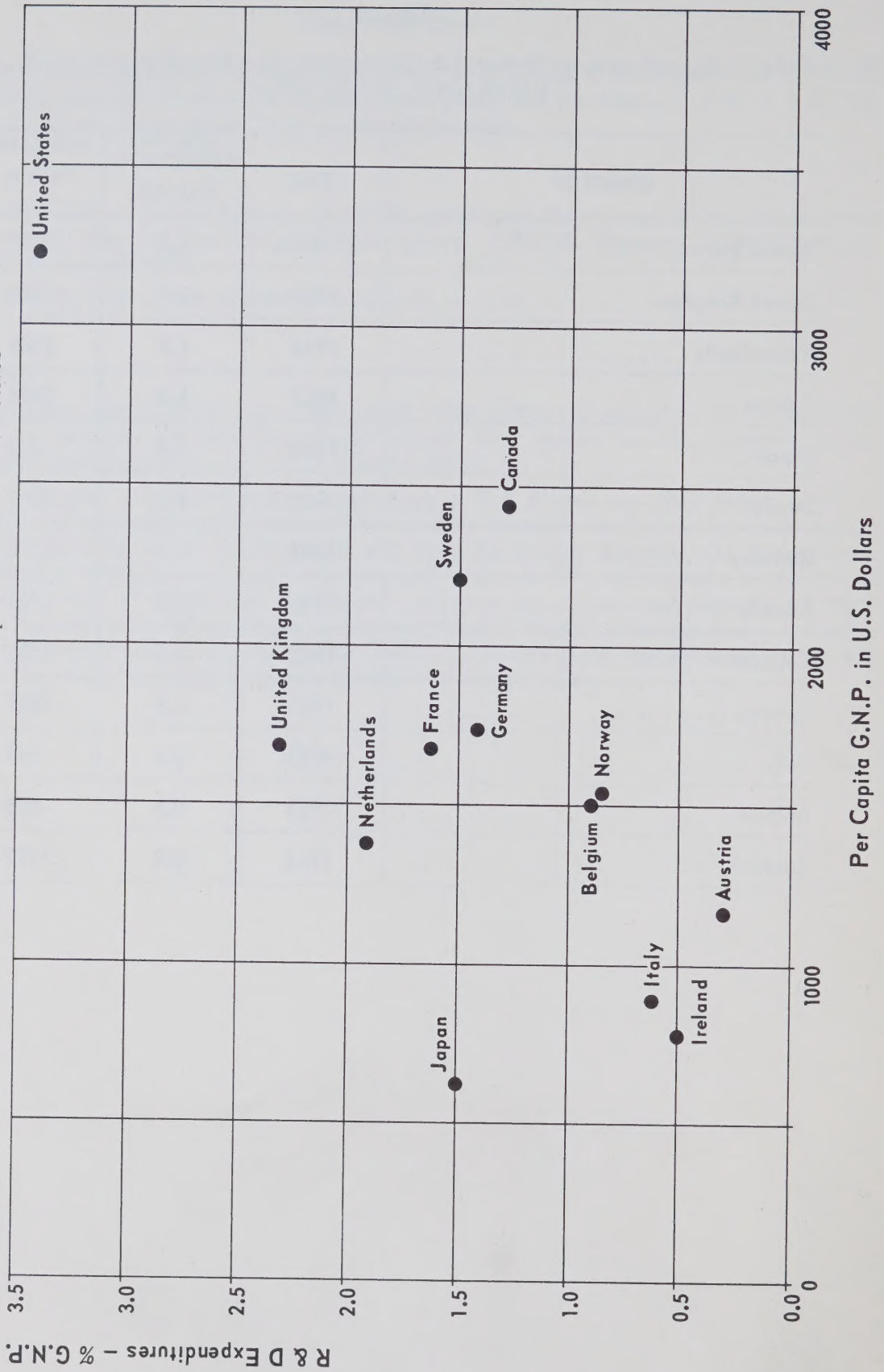


Chart 2

Gross National Expenditures (current and capital) on Research & Development as a Percentage of Gross National Product (at current market price) by Years, for a number of countries.

Sources

O.E.C.D., *Science, Economic Growth and Government Policy*, Paris, 1963; supplemented by O.E.C.D., *Statistical Tables and Notes, International Statistical Year on Research and Development*, O.E.C.D. Document DAS/SPR/66.14, Paris, 23 January 1967; D.B.S.; and APPENDIX, Table C.

Commentary

It will be seen that R & D expenditures in all the countries shown in this chart have been increasing faster than the Gross National Product. The ordinate scale is logarithmic; hence a constant compound growth rate is depicted as a straight line.

Note the high growth rates in France and the Netherlands in recent years, and also the rising growth rate in Canada since the cutback in expenditures following the termination of the Arrow aircraft program in 1959.

Chart 2

Gross National Expenditures on Research & Development
as a Percentage of G.N.P. by Years

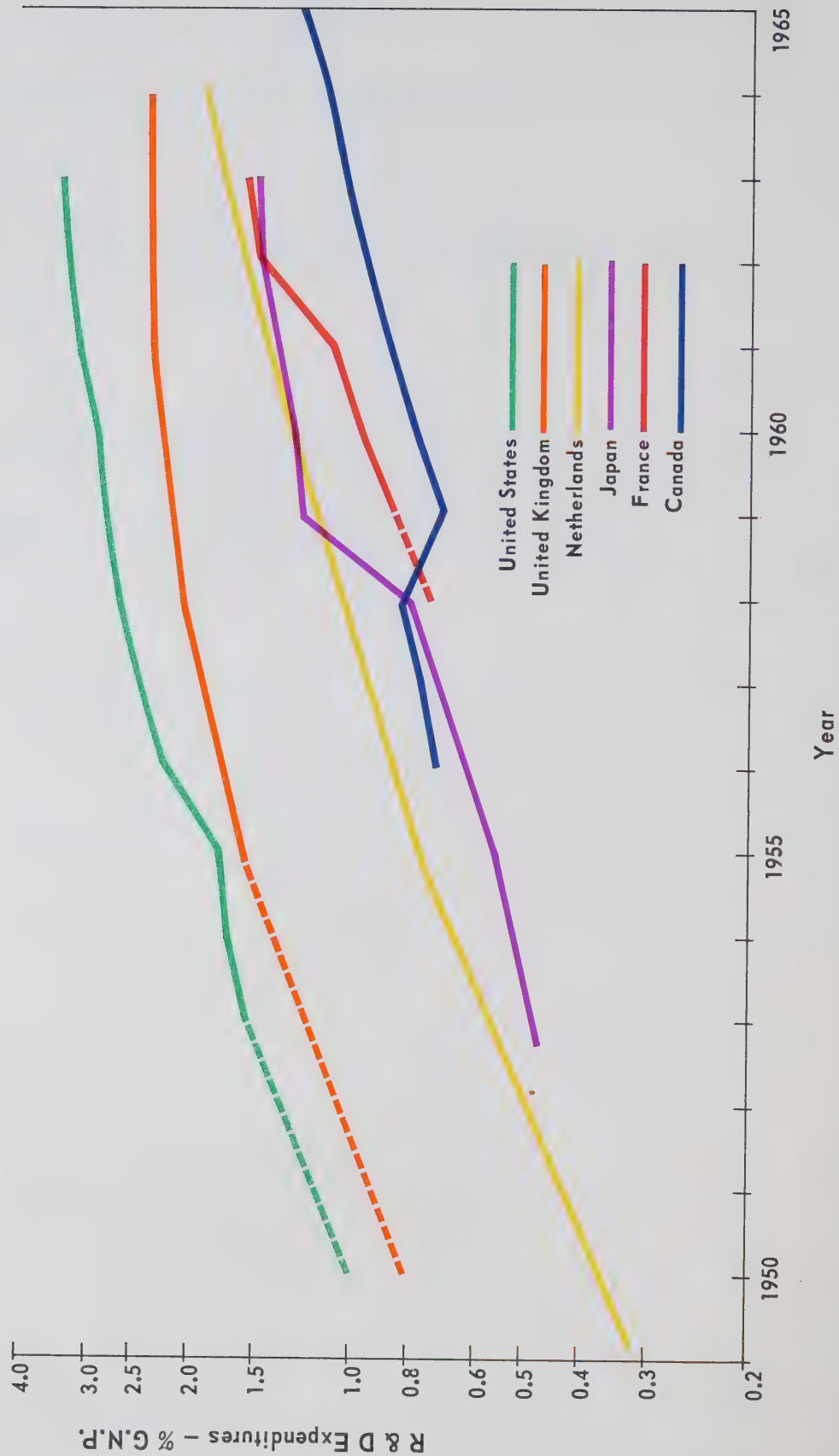


Table 2 and Charts 3 & 4

Gross National Expenditures (current and capital) on Research & Development by Sector of Performance and by Source of Funds, as a Percentage of Gross National Product (at current market price) and as a Percentage of Total Expenditures, for a number of countries.

Sources

- (a) For all countries except Canada: O.E.C.D., *Statistical Tables and Notes, International Statistical Year on Research and Development*, O.E.C.D. Document DAS/SPR/66.14 Paris, 23 January 1967.
- (b) For Canada: D.B.S.; and APPENDIX, Table C.

Commentary

The table and charts show how Canada compares with other countries in respect of R & D expenditures. It will be noted that the United States spends a higher percentage of its G.N.P. (3.4%) on research and development than any of the other countries listed. It is followed by the United Kingdom, the Netherlands, France, Japan, Sweden and Germany. Canada ranks 8th in the list, spending about 1.3% of its G.N.P. on R & D in 1965.

Sector of Performance

In Canada, a much smaller proportion (42%) of the total R & D expenditures is made by industry than in any of the other countries, and conversely a larger proportion (36%) is made by government R & D establishments than in any of the other countries with the exception of France (38%). There are two reasons for this:

- 1) Expenditures by government R & D establishments in Canada are relatively large. In terms of G.N.P., they are exceeded only by countries with large defence programs, i.e., the United States, the United Kingdom and France.
- 2) Expenditures by Canadian industry are relatively small. In terms of G.N.P., they are less than in any of the other countries shown, as may be seen from Chart 3.

Source of Funds

In Canada, the government sector provides a larger proportion (52%) of the total funds for R & D, than in any of the other countries except the big defence spenders (i.e., the United States, the United Kingdom, and France). Most of the funds provided by the government sector in Canada are spent in government R & D establishments. Although Canadian industry provides 31% of the total Canadian R & D funds, it contributes less than industry in any of the other countries in terms of G.N.P., as shown in Chart 3.

Table 2

Gross National Expenditures on Research & Development, by Sector of Performance and by Source of Funds

COUNTRY	YEAR	R&D EX- PENDITURES % G.N.P.	SECTOR OF PERFORMANCE				SOURCE OF FUNDS			
			GOVERN- MENT	INDUSTRY	HIGHER EDUCATION	PRIVATE NON- PROFIT	GOVERN- MENT	INDUSTRY	HIGHER EDUCATION	PRIVATE NON- PROFIT
			- PERCENTAGES -				- PERCENTAGES -			
United States	1963/64	3.4	18	66	13	3	63	32	4	1
United Kingdom . .	1964/65	2.3	25	67	7	1	54	42	-	1
Netherlands	1964	1.9	3	58	17	22	37	57	-	3
France	1963	1.6	38	51	11	-	64	33	-	-
Japan	1963	1.5	12	65	19	4	28	65	4	3
Sweden	1964	1.5	15	67	18	-	48	49	1	1
Germany	1964	1.4	3	66	20	11	41	57	-	1
Canada	1965	1.3	36	42	21	1	52	31	10	2
Belgium	1963	0.9	10	75	14	1	23	72	1	-

Chart 3

Gross National Expenditures on Research & Development,
by Sector of Performance and by Source of Funds

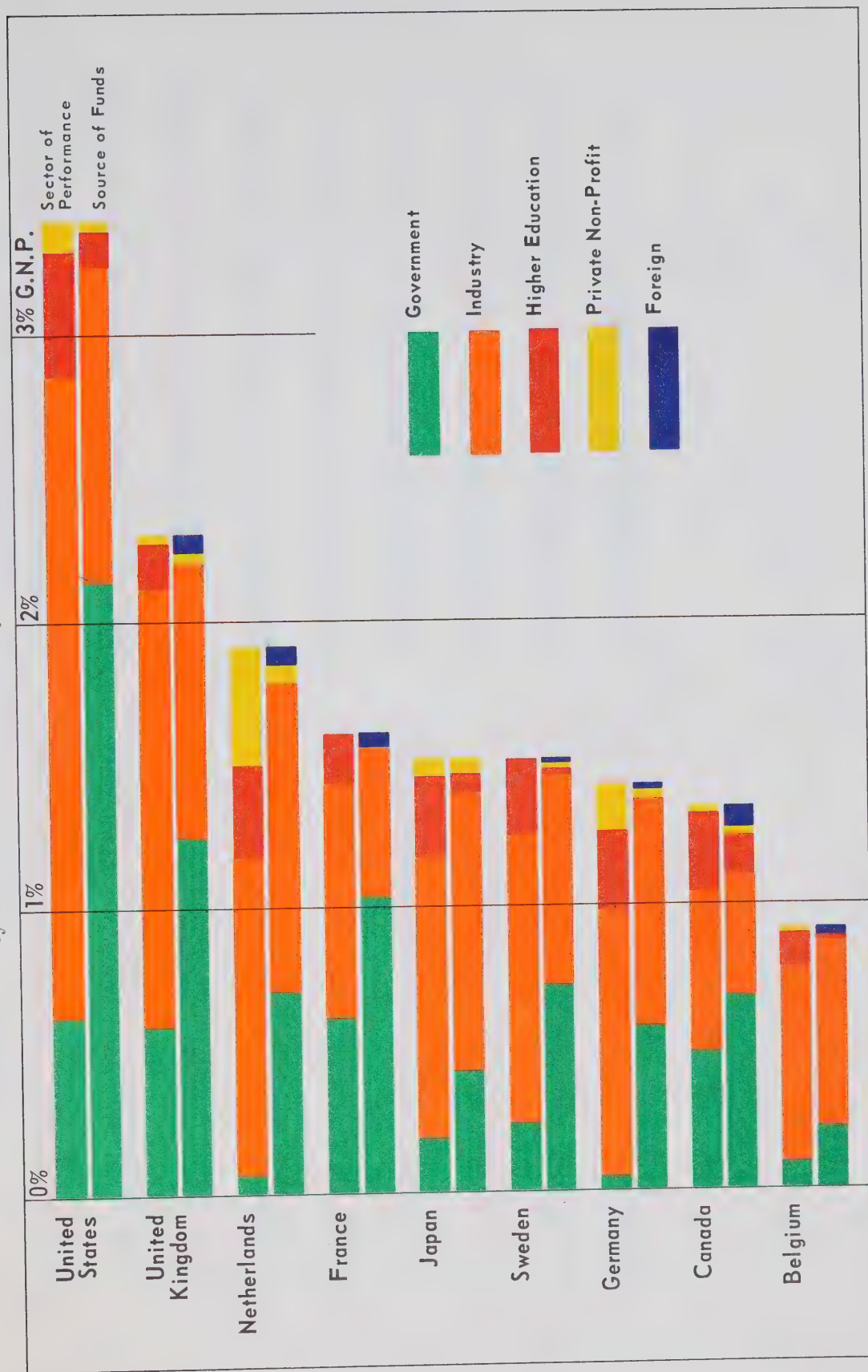


Chart 4

Gross National Expenditures on Research & Development,
by Sector of Performance and by Source of Funds



Table 3 and Chart 5

Current Expenditures on Research & Development by Sector of Performance and by Type of Research-Development Activity as a Percentage of Total Expenditures, for a number of countries.

Sources

- (a) For all countries except Canada: O.E.C.D., *Statistical Tables and Notes, International Statistical Year on Research and Development*, O.E.C.D. Document DAS/SPR/66.14, Paris, 23 January 1967; and O.E.C.D. *Preliminary Analysis of the Main Results, International Statistical Year on Research and Development*, O.E.C.D. Document SP (67)4, Paris, 6 March 1967.
- (b) For Canada: D.B.S.; and APPENDIX, Table D.

Commentary

In both the United States and the United Kingdom, less than 40% of total expenditures is devoted to basic and applied research, while more than 60% is for development, much of which is undoubtedly related to defence and space requirements. In the Netherlands and Canada, on the other hand, the situation is almost reversed, with about 60% of total expenditures in each country going for research (basic and applied) and only about 40% for developmental activity. In France, expenditures are divided almost equally between basic and applied research (51%), and development (49%).

This relatively high proportion of expenditures on research in the Netherlands can probably be explained, in part, by the fact that five or six large international corporations do most of their research in the Netherlands. In Canada, it is a reflection of the high percentage of total R & D expenditures made by government establishments. In both countries, the relatively small proportion of total funds spent on development compared to the United States, the United Kingdom and France is probably a reflection of their more modest defence and space programs.

Table 3

Current Expenditures on Research & Development by Sector of Performance and by Type of Research-Development Activity

COUNTRY	R & D EX-PENDITURES % GNP	SECTOR OF PERFORMANCE	TYPE OF ACTIVITY			
			BASIC RESEARCH	APPLIED RESEARCH	DEVELOP- MENT	TOTAL
United States 1964	3.0	Government	2	5	8	15
		Industry	3	14	54	71
		Higher Education	6	2	3	11
		Private Non-Profit	1	1	1	3
		Total	12	22	66	100
United Kingdom 1964/65	1.9	Government	3	9	14	26
		Industry	3	16	48	67
		Higher Education	6	1	-	7
		Private Non-profit	-	-	-	-
		Total	12	26	62	100
France 1963	1.9	Government	4	16	17	37
		Industry	2	16	32	50
		Higher Education	11	2	-	13
		Private Non-profit	-	-	-	-
		Total	17	34	49	100
Netherlands 1964	1.5	Government	1	2	1	4
		Industry	11	16	31	58
		Higher Education	10	4	2	16
		Private Non-profit	4	15	3	22
		Total	26	37	37	100
Canada 1965	1.0	Government	7	23	6	36
		Industry	2	12	30	44
		Higher Education	13	5	1	19
		Private Non-profit	-	1	-	1
		Total	22	41	37	100

Chart 5

Current Expenditures on Research & Development
by Sector of Performance and by Type of Research – Development Activity

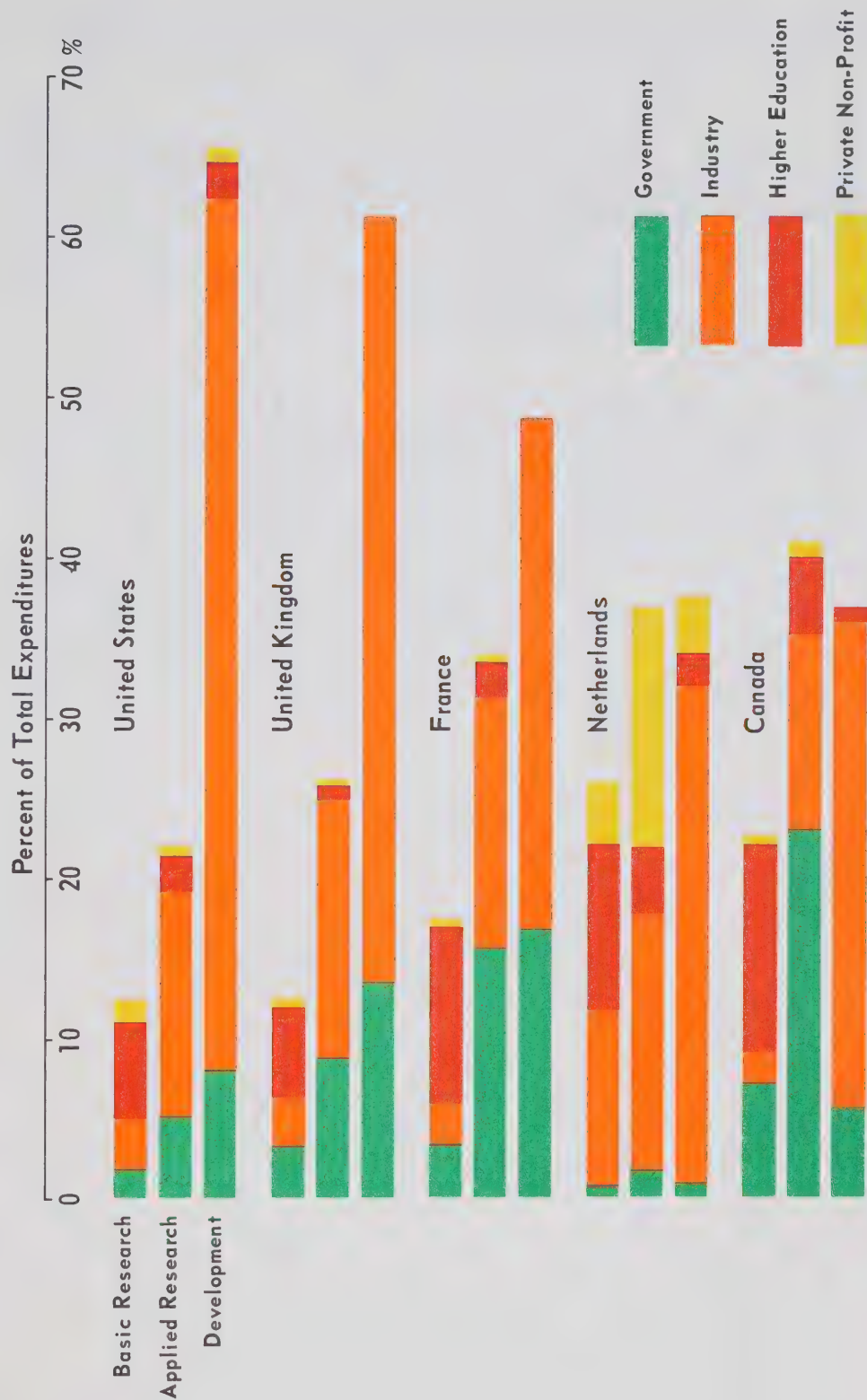


Table 4 and Charts 6 & 7

Source of Funds for Intra-mural Research & Development by Industry as a Percentage of Total Value Added and as a Percentage of Total Funds, for a number of countries.

Sources

- (a) For all countries except Canada and the U.S.A.: O.E.C.D.; *Statistical Tables and Notes, International Statistical Year on Research and Development*, O.E.C.D. Document DAS/SPR/66.14, Paris, 23 January 1967.
- (b) For Canada: D.B.S.
- (c) For the U.S.A.: National Science Foundation, *Reviews of Data on Science Resources*, NSF 66-33, No. 10, Washington, December 1966.

Commentary

Canadian industry's expenditures on R & D amount to 1.72% of its net output in terms of total value added by manufacturing and non-manufacturing activities*. By comparison, industry in the United States spends 6.16% of its net output or 3.6 times as much, industry in the United Kingdom spends 3.88% of its net output or 2.3 times as much, and industry in Sweden spends 2.77% of its net output or 1.6 times as much as Canadian industry.

In Canada, the government sector finances 18% of the R & D performed by industry, which is larger than the proportion of industrial research and development financed by government in the Netherlands, Japan, Germany or Belgium, but which is less than the proportion financed by government in the United States, the United Kingdom, France and Sweden where defence and space programs account for much of the industrial R & D activity.

*Value of total operational revenue less total cost of materials, supplies, fuel and electricity used and goods purchased for re-sale, all adjusted for inventory changes where required.

Table 4

Source of Funds for Intra-mural Research & Development by Industry.

COUNTRY	YEAR	R & D EXPENDITURES ⁽¹⁾ % TOTAL VALUE ADDED	SOURCE OF FUNDS		
			GOVERNMENT	INDUSTRY	FOREIGN & OTHER
			- PERCENTAGES -		
United States	1965	6.16 ⁽²⁾	55	45	-
United Kingdom	1964	3.88	37	60	3
Netherlands	1964	n.a.	1	93	6
France	1963	n.a.	32	65	3
Japan	1963	2.10	-	100	-
Sweden	1964	2.77	27	73	-
Germany	1964	n.a.	14	86	-
Canada	1965	1.72	18	73	9
Belgium	1963	n.a.	4	94	2

⁽¹⁾For manufacturing industries only⁽²⁾Includes allowance for depreciation, but no capital expenditures

Chart 6

Source of Funds for Intra-mural Research & Development by Manufacturing Industries

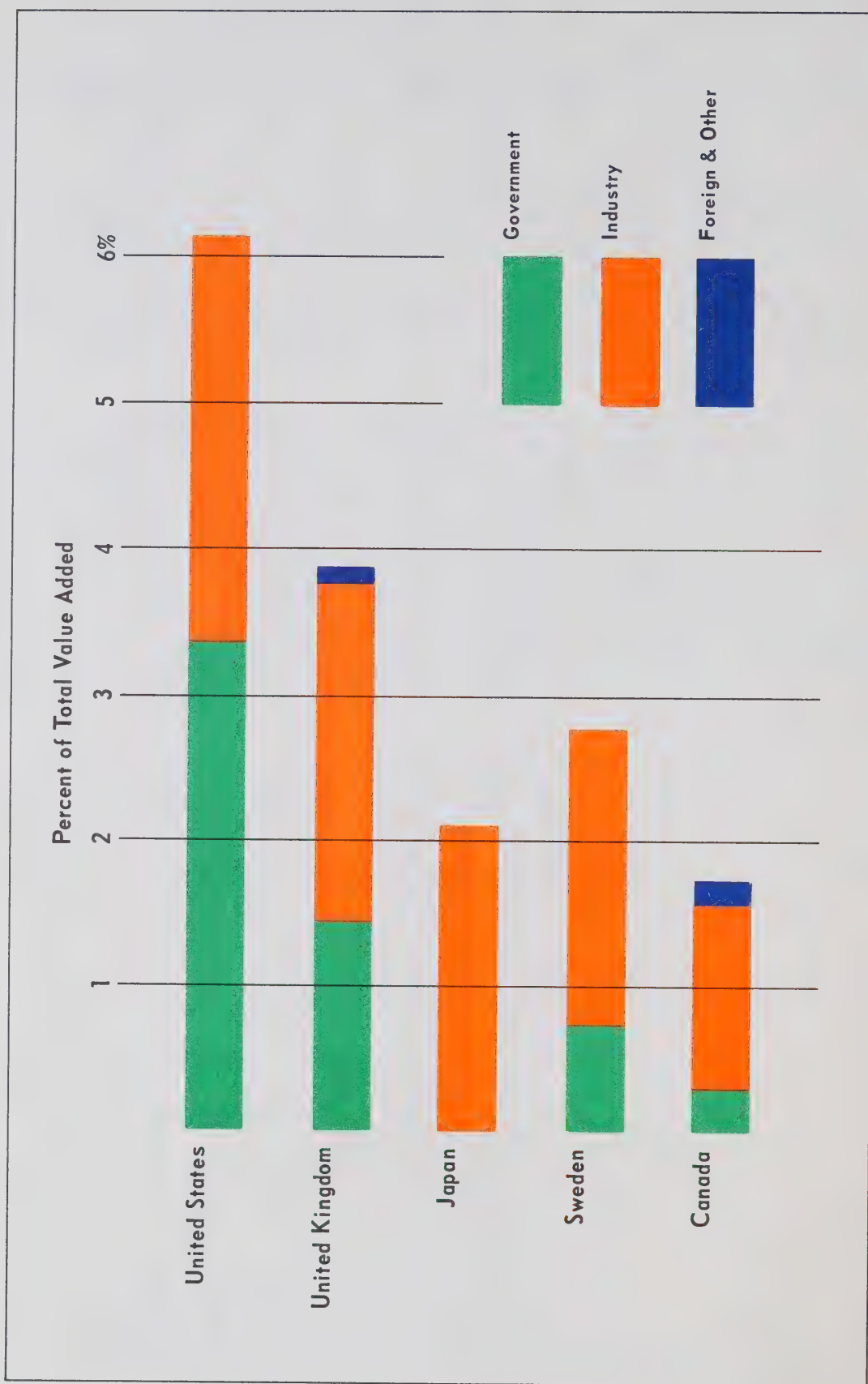


Chart 7

Source of Funds for Intra-mural Research & Development by Industry

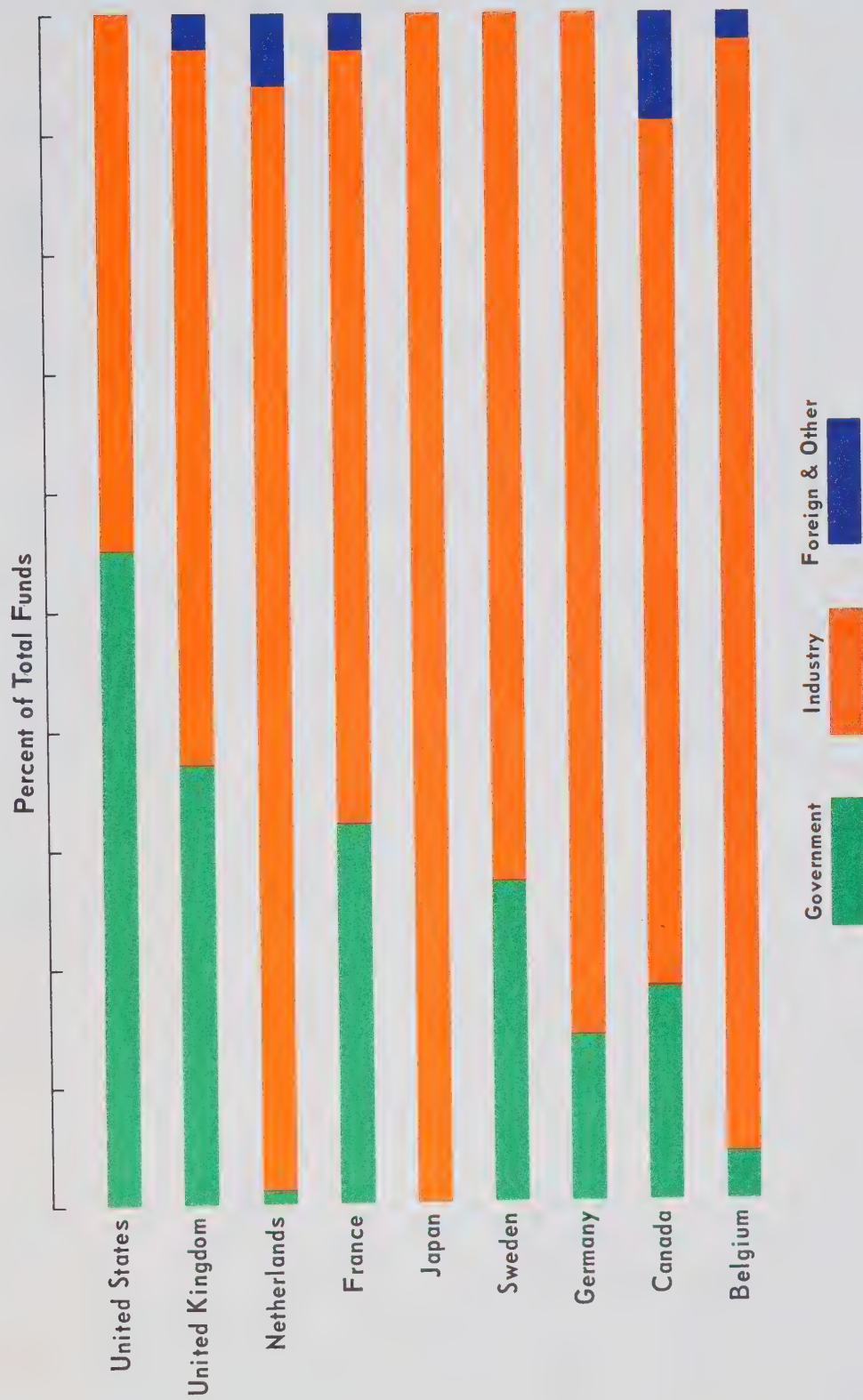


Table 5

Distribution of Intra-mural Research & Development Expenditures (current and capital) by Industry, for a number of countries.

Sources

- (a) For all countries except Canada: O.E.C.D., *Statistical Tables and Notes, International Statistical Year on Research and Development*, O.E.C.D. Document DAS/SPR/66.14, Paris, 23 January 1967.
- (b) For Canada: D.B.S.

Commentary

This table shows the pattern of industrial research and development expenditures in a number of countries. For purposes of comparison, manufacturing industries have been divided into three groups:

Group A – Industries primarily engaged in the production of capital goods and chemicals.

Group B – Industries primarily engaged in the production of basic materials.

Group C – Industries primarily engaged in the production of consumer goods and miscellaneous products.

It will be seen that the distribution of expenditures in most countries is similar. In all countries the majority of expenditures (over 65%) are made by industries in Group A, in which the largest spenders are the Transportation Equipment Industry (includes aircraft and automobiles) and the Electrical Products Industry. In most countries the industries in Group B rank second (but far behind the industries in Group A), while the industries in Group C rank third. Non-manufacturing industries such as Mines, Oil Wells, Agriculture, Utilities, Transportation, Communications, etc., account for less than 10% of industrial R & D expenditures in most countries.

Table 5

Distribution of Intra-mural Research & Development Expenditures by Industry

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Table 6 and Chart 8

Number of Canadian Firms Reporting Research & Development Expenditures, 1957 - 1965.

Source

D.B.S.

Commentary

These figures show the number of firms which made expenditures on research and development in the years 1957 to 1965 under the following headings:

1. Intra-mural Expenditures (i.e. firms which made expenditures for R & D performed within the firm)
2. Canadian Extra-mural Expenditures (i.e. firms which performed no intra-mural R & D but which made expenditures for R & D in Canada)
3. Foreign Extra-mural Expenditures (i.e. firms which made payments for R & D performed outside Canada, but did not make expenditures for R & D in Canada)

In 1965 there were 800 firms in Canada making R & D expenditures, up 14% from 1963, and up 70% from 1959. The number of firms engaged in intra-mural R & D in 1965 was 687, up 18% from 1963, and up 87% from 1959. The number of firms making foreign extramural payments only dropped from 59 in 1961 to 39 in 1965. This may have been influenced by the tax incentive for scientific research introduced in 1962.

Since there were about 34,000 manufacturing establishments in Canada in 1965, the number engaged in research and development (i.e. 687) represents about 2% of the total.

Table 6
Number of Canadian Firms Reporting Research & Development Expenditures, 1957-1965

TYPE OF EXPENDITURE	YEAR				
	1957	1959	1961	1963	1965
Intramural.....	367	367	416	582	687
Canadian Extramural.....	n.a.	65	48	68	74
Total in Canada.....	n.a.	432	464	650	761
Foreign Extramural Only.....	n.a.	39	59	51	39
Total.....	455	471	523	701	800

Chart 8

Number of Canadian Firms Reporting Research & Development Expenditures, 1957-1965

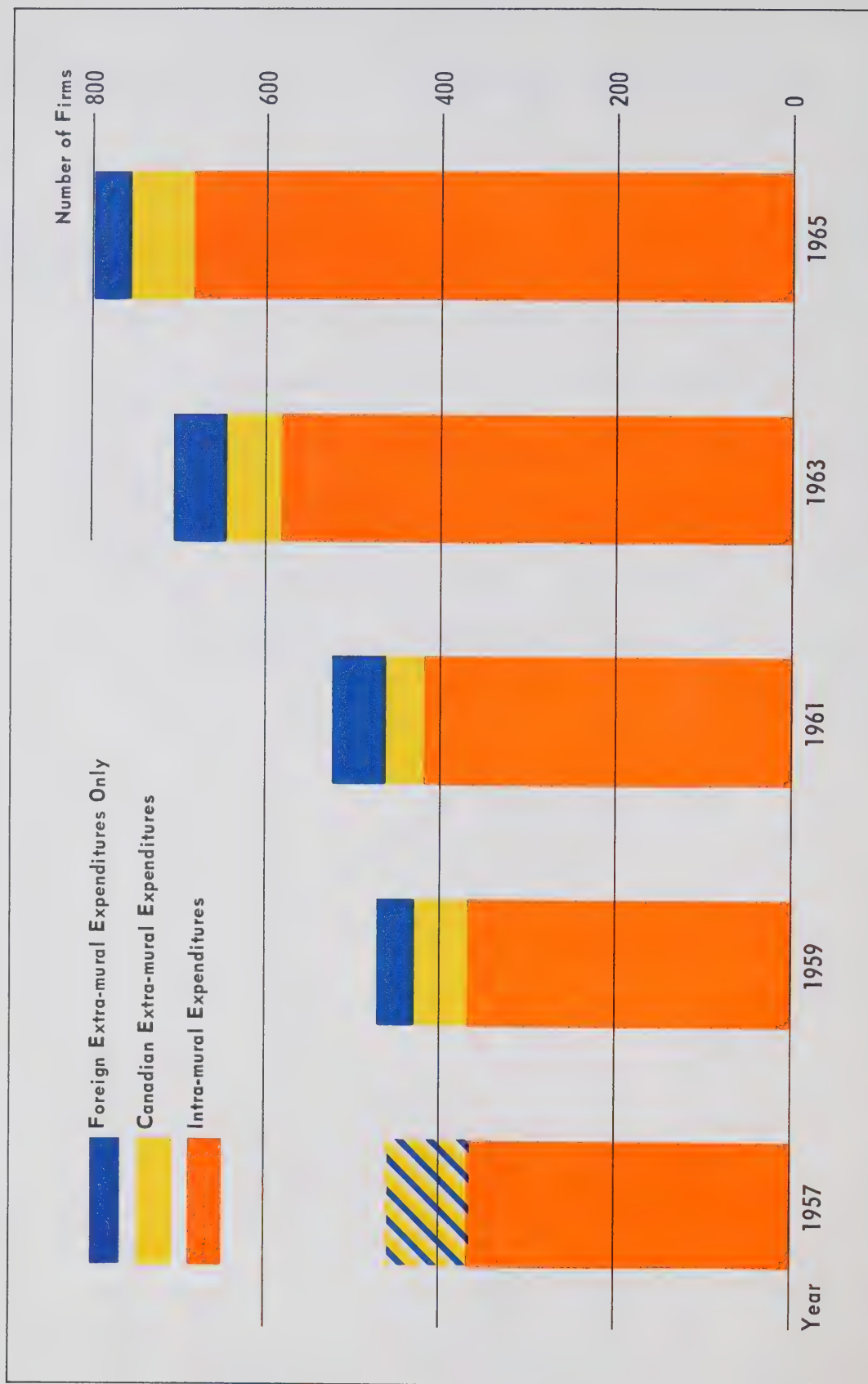


Table 7 and Charts 9 & 10

Industrial Research and Development in Canada, 1957-1965 by Source and Application of Funds.

Source

D.B.S.

Commentary

In 1965, current intra-mural expenditures for R & D by Canadian industry amounted to \$234.1 million, up from \$153.1 million in 1963 for an average annual growth rate of 24% per annum, and almost 2½ times expenditures in 1959. There has been a steady increase in industry funds for R & D from \$63.0 million in 1957 to \$158.7 million in 1965. On the other hand, the termination of the Arrow aircraft development in 1959 resulted in a drastic reduction in government funds for industrial R & D, and although they have increased substantially from the low of \$18.2 million in 1961, they were still below the 1957 level in 1965. Foreign sources provided \$25.5 million in 1965 which was almost 3½ times the \$7.4 million provided in 1963. Expenditures by foreign governments (principally the U.S. Government) for the development of military equipment in Canada accounted for most of this substantial increase in foreign funds.

Canadian and foreign extra-mural expenditures have remained relatively unchanged over the period, although foreign extra-mural expenditures have dropped slightly since 1961. Capital expenditures, on the other hand, have shown a remarkable increase in recent years. In 1965, capital expenditures amounted to \$49.8 million, up 82% from 1963, and more than 4½ times capital expenditures in 1959.

Of the total of \$283.9 million spent by industry on intra-mural research and development (current and capital) in 1965, industry provided \$208.5 million or 73.4%, government provided \$49.9 million or 17.6%, and foreign sources provided \$25.5 million or 9.0%.

Table 7

Industrial Research & Development in Canada, 1957-1965 by Source and Application of Funds

	YEAR				
	1957	1959	1961	1963	1965
	- \$ MILLIONS -				
Current intra-mural expenditures:					
Industry funds.....	63.0	75.5	95.8	117.5	158.7
Government funds	61.5	21.1	18.2	28.2	49.9
Foreign funds.....	n.a.	n.a.	n.a.	7.4	25.5
Total current intra-mural expenditures.....	124.5	96.6	114.0	153.1	234.1
Capital expenditures.....	12.6	10.7	13.5	27.4	49.8
Total intra-mural expenditures	137.1	107.3	127.5	180.5	283.9
Net Canadian extra-mural expenditures	4.2	3.3	1.9	3.3	3.1
Total expenditures in Canada	141.3	110.6	129.4	183.8	287.0
Foreign extra-mural expenditures	19.8	21.7	31.2	26.9	27.1
Total expenditures	161.1	132.3	160.6	210.7	314.1

Chart 9

Source of Funds for Intra-mural Research & Development by Canadian Industry, 1957-1965

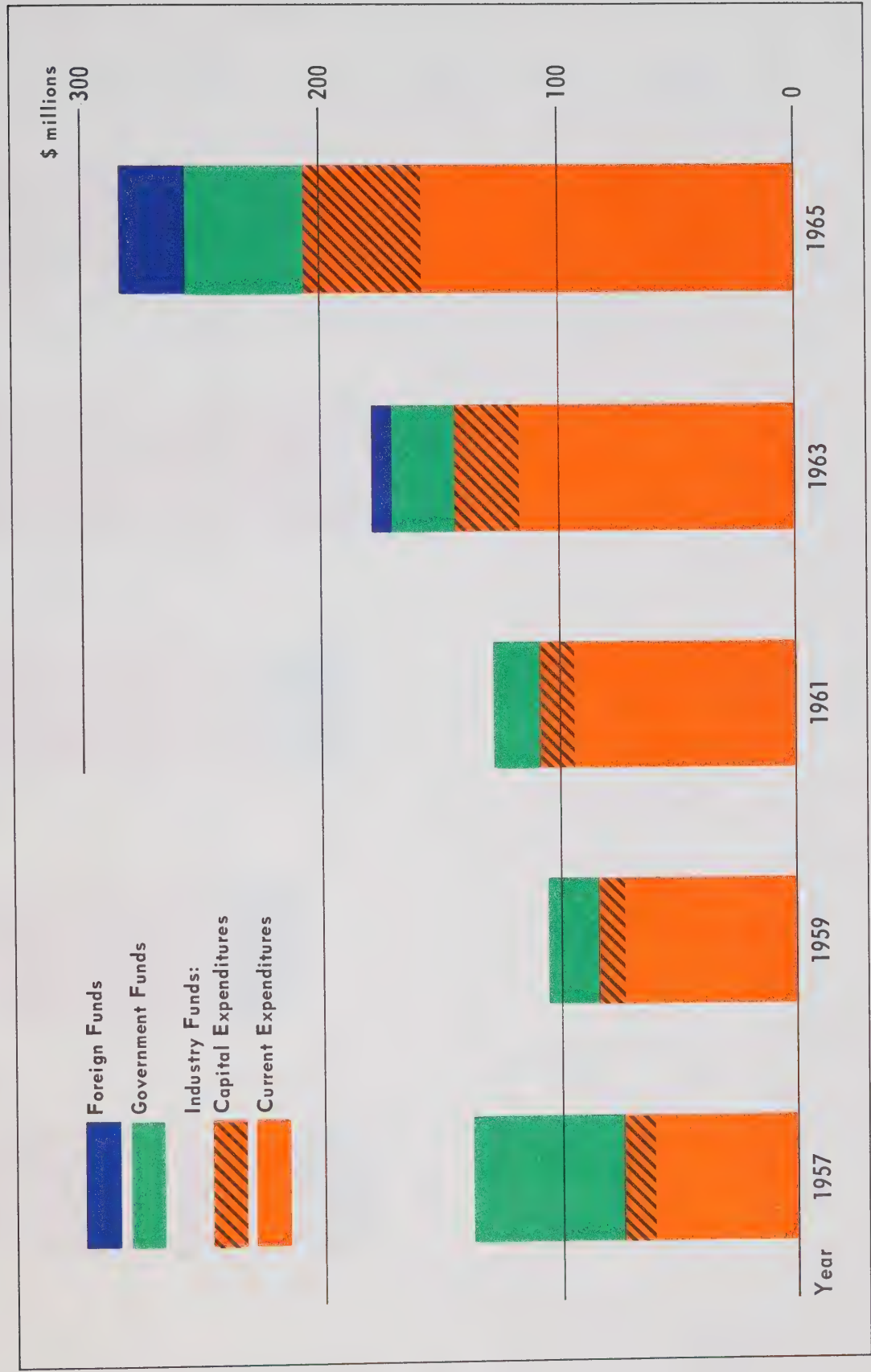


Chart 10
 Research & Development Expenditures by Canadian Industry, 1957-1965

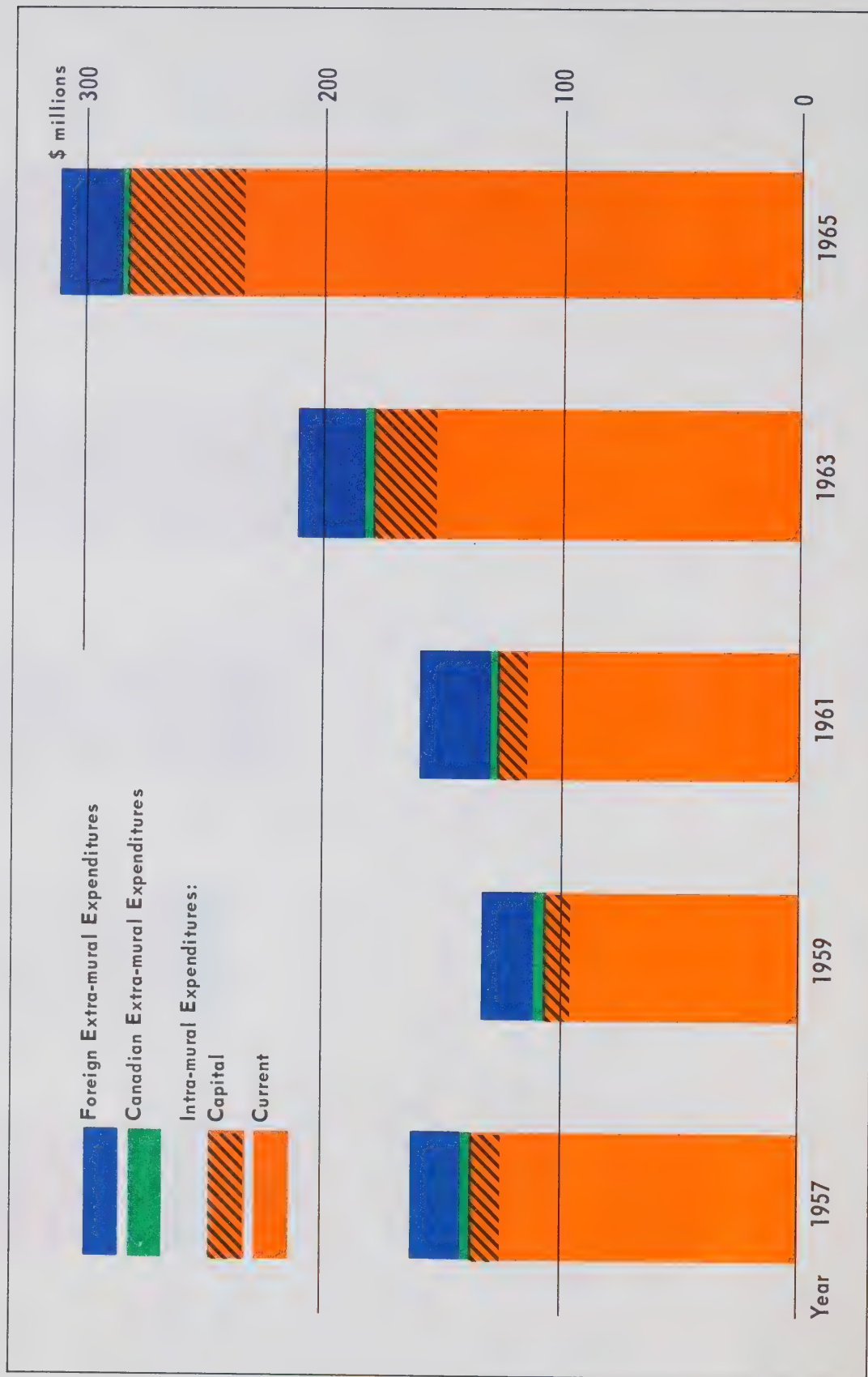


Table 8 and Chart 11

Number of Personnel Engaged in Research & Development in Canadian Industry, 1957-1965.

Source

D.B.S.

Commentary

The total number of personnel engaged in research and development in Canadian industry in 1965 was 15,705, up 11% from 1963 and up 58% from 1959. The growth rate in each of the categories (i.e. Bachelor, Master, Doctorate and supporting personnel) has been about the same, since the distribution by category has remained almost unchanged over this period. In 1965 the distribution was as follows:

	<u>% of Total</u>
Professional Personnel:	
Bachelor	31
Master	4
Doctorate	<u>5</u>
Total, Professional Personnel	40
Supporting Personnel	<u>60</u>
Total R & D Personnel	100

Table 8

Number of Personnel Engaged in Research & Development in Canadian Industry, 1957-1965

	YEAR				
	1957	1959	1961	1963	1965
	- NUMBER -				
Professional Personnel:					
Bachelor.....	3,429	3,111	3,608	4,426	4,805
Master	428	480	496	712	752
Doctorate.....	497	550	569	657	784
Total, Professional Personnel.....	4,354	4,141	4,673	5,795	6,341
Supporting Personnel	7,125	5,808	7,159	8,364	9,364
Total R & D Personnel.....	11,479	9,949	11,832	14,159	15,705

Chart 11

Number of Personnel Engaged in Research & Development in Canadian Industry, 1957-1965

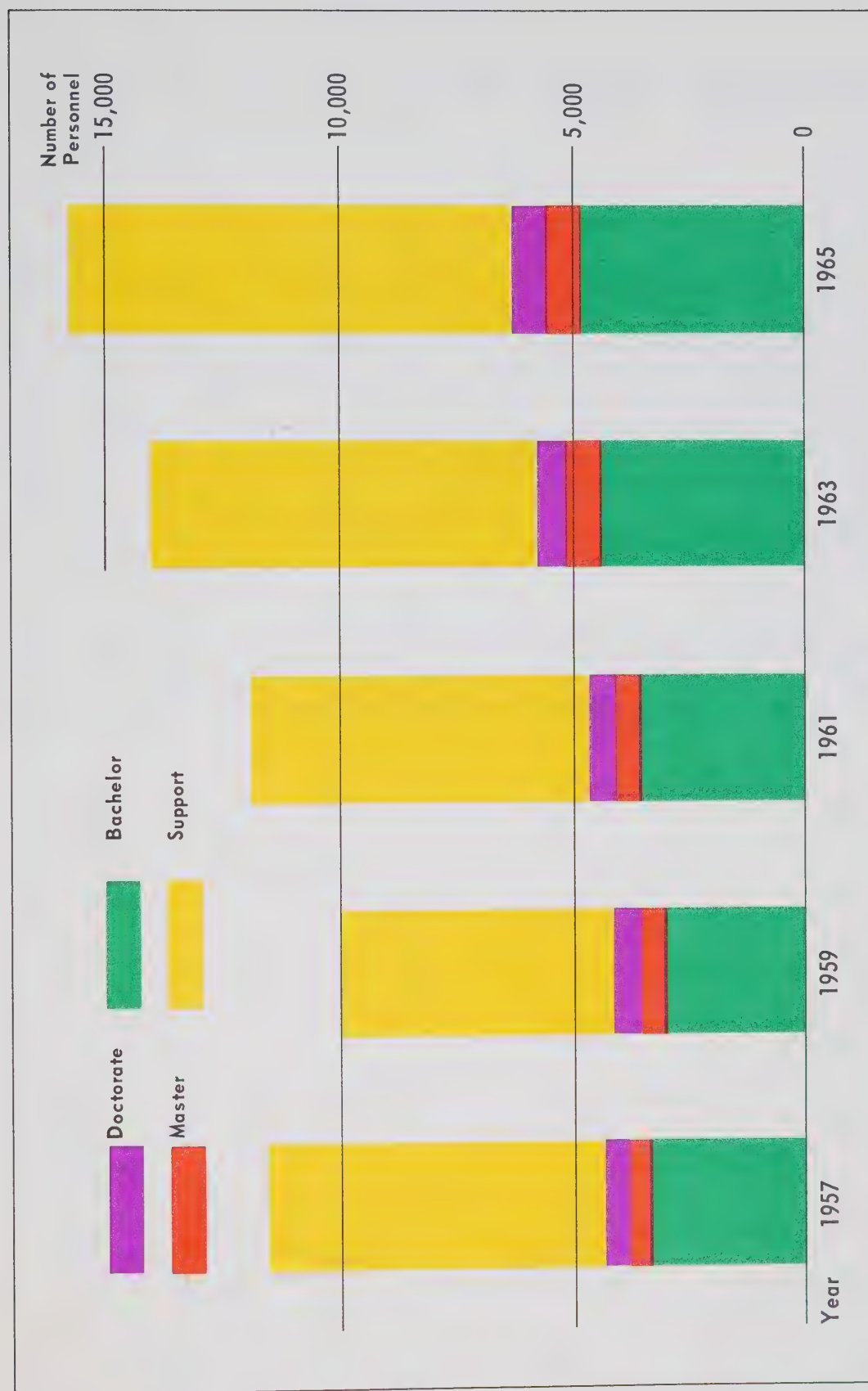


Table 9 and Chart 12

Current Industrial Research & Development Expenditures (intra-mural and extra-mural) in Canada, 1959 and 1965, by Size of Firm.

Source

D.B.S.

Commentary

The table and chart show the distribution of current R & D expenditures in 1959 and 1965 by size of firm in terms of annual gross sales (excluding re-sales).

In both years, more than 50% of the total expenditures were made by firms whose annual sales exceeded \$50 million, while firms with sales of less than \$1 million per annum accounted for less than 3% of industry's total expenditures on R & D.

Between 1959 and 1965, expenditures by firms in the first two size groups (i.e. under \$1 million and \$1 – \$10 million) doubled; expenditures in the third size group (i.e. \$10 – \$50 million) increased by about 44%; while expenditures in the 4th size group (i.e. over \$50 million) increased almost 3 times. As a result, firms with annual sales of over \$50 million increased their share of total expenditures from 54.3% in 1959 to 68.1% in 1965, while the percentage of total expenditures made by firms with sales of \$10 to \$50 million per annum dropped from 31.0% to 19.3%.

In 1961 and 1963, 16 firms accounted for 50% of the total current intra-mural expenditures for R & D by Canadian industry. In 1965, 12 firms accounted for 50% of the total current intra-mural expenditures for R & D by Canadian industry. This would seem to indicate that the larger firms are increasing their expenditures at a faster rate than the smaller firms.

Table 9

Current Industrial Research & Development Expenditures in Canada, 1959 and 1965 by Size of Firm

SIZE OF FIRM ANNUAL GROSS SALES	NET CURRENT R & D EXPENDITURES IN CANADA			
	1959		1965	
	\$ MILLIONS	% TOTAL	\$ MILLIONS	% TOTAL
Under \$1 million	2.4	2.4	4.8	2.1
\$ 1 - \$10 millions	12.2	12.3	23.9	10.5
\$10 - \$50 millions	30.7	31.0	44.1	19.3
Over \$50 millions	53.8	54.3	155.3	68.1
Total	99.1	100.0	228.1	100.0

Chart 12

Current Industrial Research & Development Expenditures in Canada, 1959 and 1965
by Size of Firm

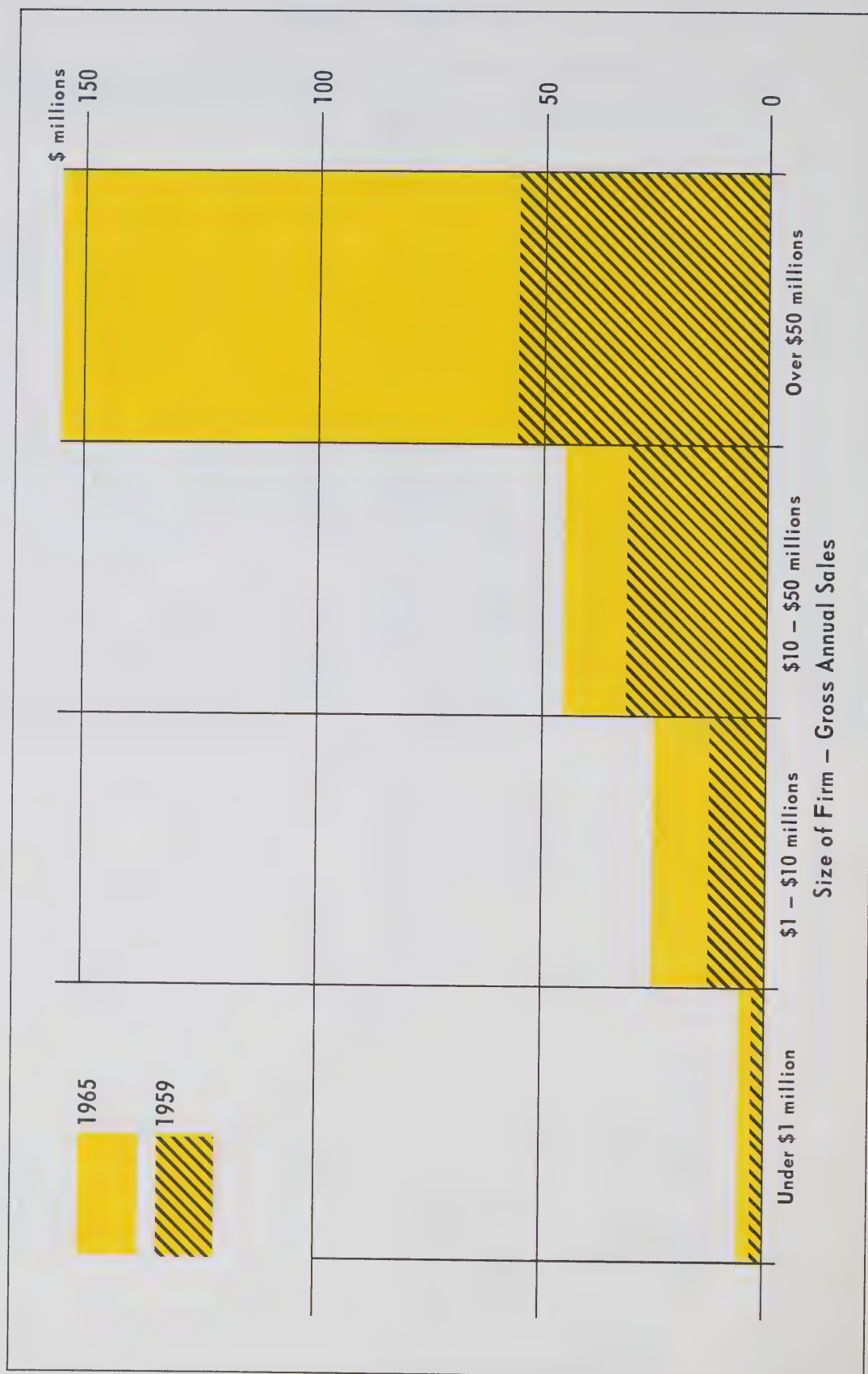


Table 10 and Charts 13 & 14

Source of Funds for Intra-mural Research & Development (current and capital expenditures) by Canadian Industries, 1965, in Dollars and as a Percentage of Total Funds.

Source

D.B.S.

Commentary

The Electrical Products Industry spent more than any other industry on R & D in 1965 but was followed closely by the Transportation Equipment Industry. Chemicals ranked third, Paper fourth, Petroleum fifth, and the Primary Metals sixth. As shown in Table 5, this distribution pattern is typical of industrial countries.

In 1965 the government spent about \$50 million for R & D in industry, primarily for defence requirements, which accounted for about 18% of industry's total expenditures. Fifty-two percent of government expenditures were made in the Transportation Equipment Industry, which includes aircraft, and 31% in the Electrical Products Industry, which includes electronic and avionic equipment.

Foreign sources provided about 9% of the total funds spent by industry. Over 50% of the foreign funds went to the Transportation Equipment and the Petroleum Industries.

Table 10

Source of Funds for Intra-mural Research & Development by Canadian Industries, 1965

INDUSTRY	TOTAL INTRA-MURAL EXPENDITURES	SOURCE OF FUNDS		
		INDUSTRY	GOVERNMENT	FOREIGN
Manufacturing:	\$ MILLIONS	- PERCENTAGES -		
Group A				
Machinery	8.2	90	1	9
Transportation Equip.	55.8	35	47	18
Electrical Products	63.0	70	25	5
Chemicals	38.8	90	3	7
Petroleum	22.7	79	-	21
Total, Group A	188.5	65	23	12
Group B				
Rubber	3.0	64	7	29
Paper	25.2	97	1	2
Primary Metals	19.1	99	1	-
Metal Products	3.6	95	5	-
Non-metallic Products	1.9	54	12	34
Total, Group B	52.8	94	2	4
Group C				
Food	7.2	96	4	-
Wood and Furniture	0.5	100	-	-
Other Manufacturing	16.1	67	30	3
Total, Group C	23.8	77	21	2
Total Manufacturing	265.1	73	18	9
Non-Manufacturing	18.8	91	6	3
Total Industry	283.9	73	18	9

Chart 13

Source of Funds for Intra-mural Research & Development by Canadian Industries, 1965

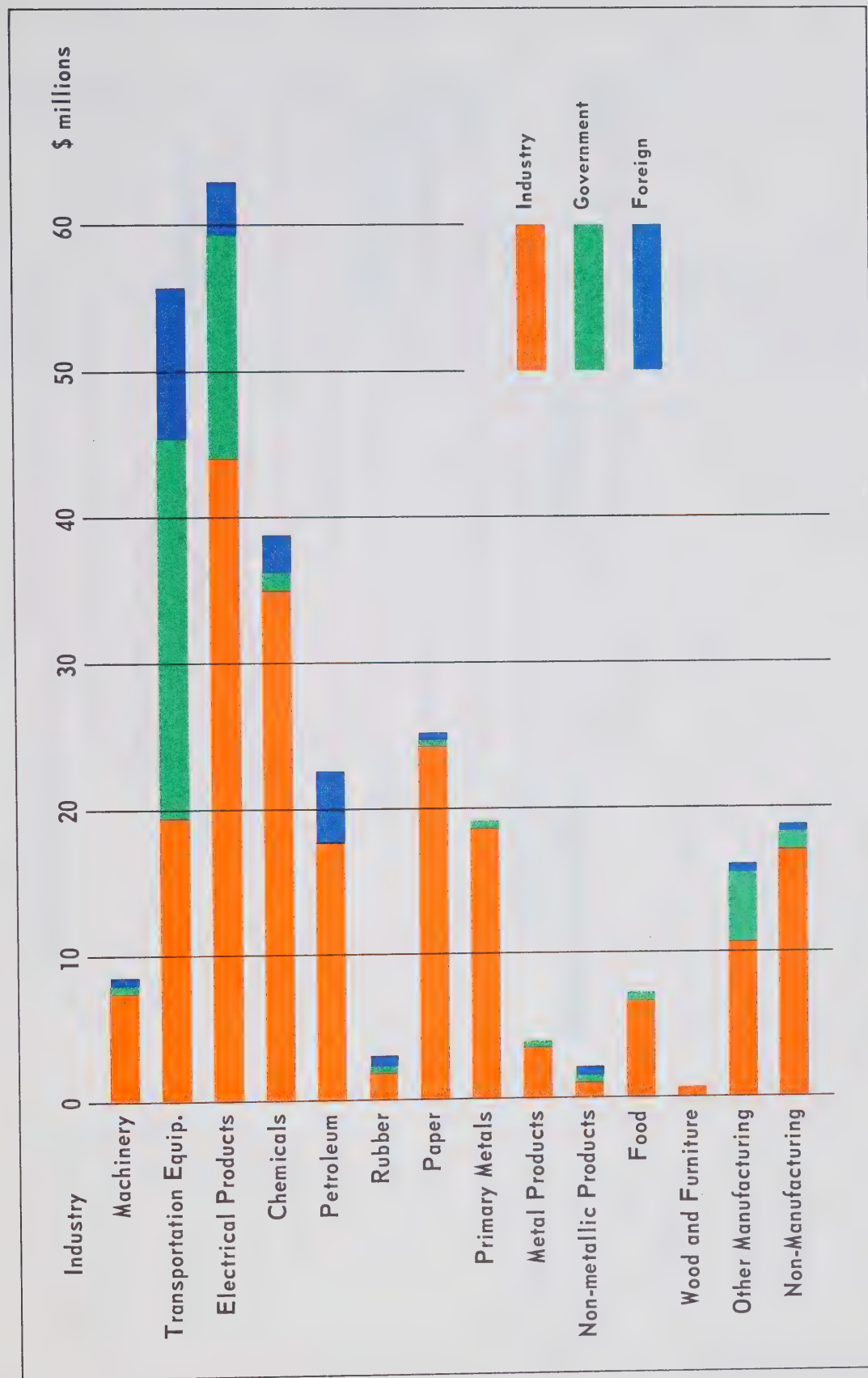


Chart 14

Source of Funds for Intra-mural Research & Development by Canadian Industries, 1965

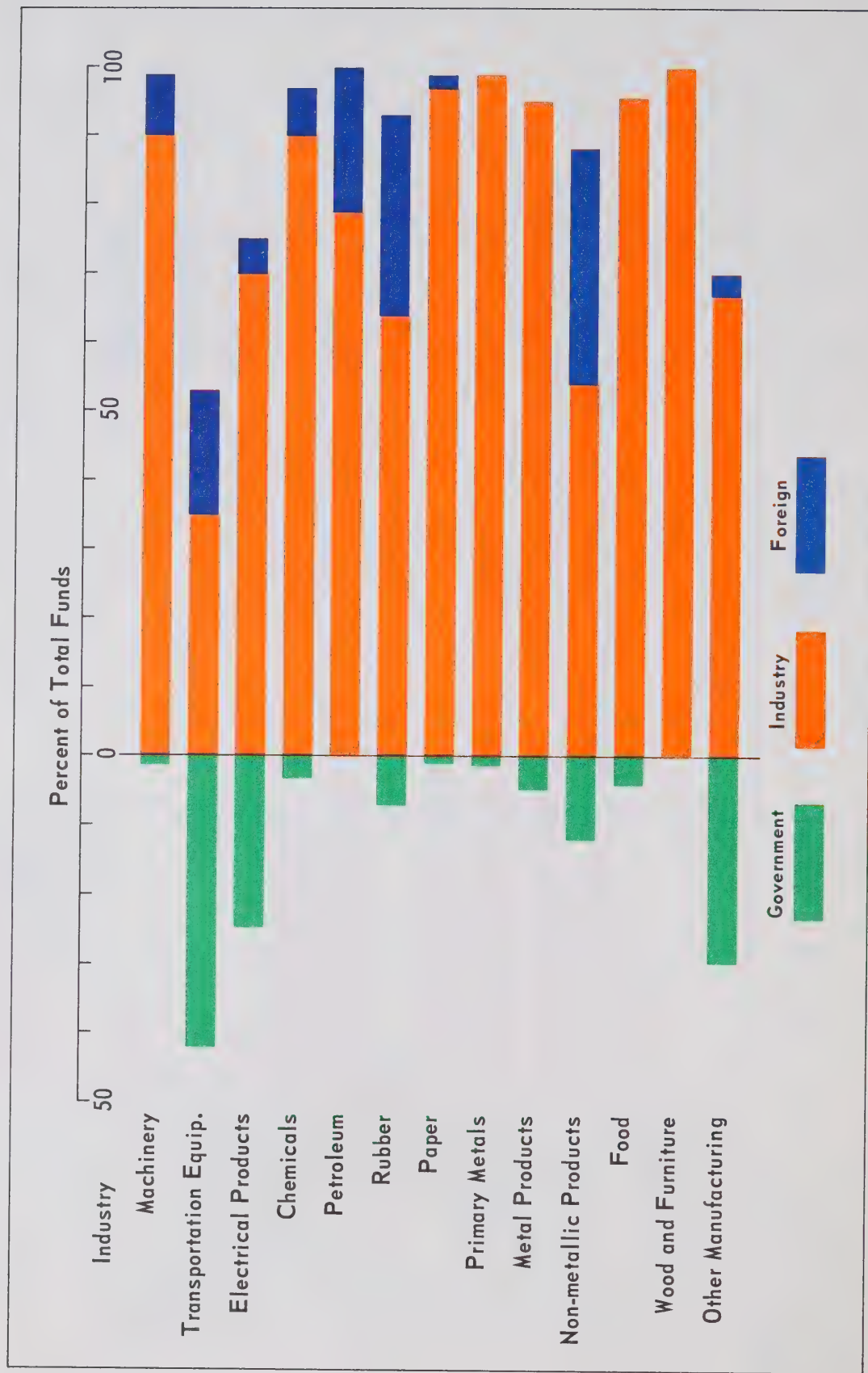


Table 11

Comparison of Current Intra-mural Research & Development Expenditures by Canadian Industries in 1959 and 1965, in Dollars.

Source

D.B.S.

Commentary

All industry groups spent more on R & D in 1965 than they did in 1959. Increases ranged from 1.3 times in the Non-metallic Products Industry to 3.5 times in the Electrical Products Industry and 4.0 times in the Wood and Furniture Industry. It should be noted, however, that in absolute terms the latter (i.e. Wood and Furniture) increase was from \$129 thousand to \$414 thousand.

Table 11

Comparison of Current Intra-mural Research & Development Expenditures by Canadian Industries in 1959 and 1965

INDUSTRY	CURRENT R & D EXPENDITURES		
	1959	1965	RATIO: $\frac{1965}{1959}$
	\$ MILLIONS		
Manufacturing:			
Group A			
Machinery	3.1	7.9	2.5
Transportation Equip.	25.6	55.8	2.2
Electrical Products	15.9	55.8	3.5
Chemicals	14.1	30.0	2.1
Petroleum	3.8	11.7	3.1
Total, Group A	62.5	161.2	2.6
Group B			
Rubber	1.2	2.5	2.1
Paper	6.6	14.5	2.2
Primary Metals	6.6	15.1	2.3
Metal Products	1.7	3.3	1.9
Non-metallic Products	1.4	1.8	1.3
Total, Group B	17.5	37.2	2.1
Group C			
Food	1.8	5.4	3.0
Wood and Furniture	0.1	0.4	4.0
Other Manufacturing	7.4	14.6	2.0
Total, Group C	9.3	20.4	2.2
Total Manufacturing	89.3	218.8	2.4
Non-Manufacturing	10.3	15.3	1.5
Total, Industry	99.6	234.1	2.4

Table 12

Comparison of Current Intra-mural Research & Development Expenditures by Industries in Canada and the United States, 1965 in U.S. Dollars (at the research exchange rate of Can. \$1.00 = U.S. \$1.20)

Sources

- (a) For Canada: D.B.S.
- (b) For the United States: National Science Foundation, *Reviews of Data on Science Resources*, NSF 66-33, No. 10, Washington, December 1966.

Commentary

The table compares current intra-mural R & D expenditures by Canadian and U.S. Industry in 1965, in terms of U.S. Dollars at the research exchange rate of Can. \$1.00 = U.S. \$1.20.*

Although in every industry group, U.S. industry spent more on R & D than Canadian industry, the difference varied widely from one industry to another. The U.S. Paper Industry spent 4 times as much on R & D as the Canadian Paper Industry, while the U.S. Machinery Industry spent 113 times as much as its Canadian counterpart.

*The comparison of R & D expenditures on an international basis is meaningless unless they are converted into a common currency, usually U.S. dollars at official rates of exchange. However, it is generally agreed that a comparison made in this way exaggerates the real differences because of variations in research and development costs between countries. (Sometimes these are so great that a comparison made in official exchange rates provides a misleading impression of the real resources devoted to research and development.) Thus a "research exchange rate" has been calculated which takes account of both the official exchange rate and differences in research costs; Canada \$1.00 = U.S. \$1.20.

Table 12

Comparison of Current Intra-mural Research & Development Expenditures by Industries in Canada and the United States, 1965
in U.S. Dollars (Can. \$1.00 = U.S. \$1.20)

INDUSTRY	CURRENT R & D EXPENDITURES IN U.S. DOLLARS		
	UNITED STATES*	CANADA	RATIO: U.S. CANADA
	- \$ MILLIONS -		
Manufacturing:			
Group A			
Machinery	1,129	10	113
Transportation Equip.	6,358	67	95
Electrical Products	3,167	67	47
Chemicals	1,377	36	38
Petroleum	435	14	31
Total, Group A	12,466	194	64
Group B			
Rubber	166	3	55
Paper	76	18	4
Primary Metals	216	18	12
Metal Products	145	4	36
Non-metallic Products	119	2	60
Total, Group B	722	45	16
Group C			
Food	150	7	21
Wood and Furniture	13	1	13
Other Manufacturing	488	17	29
Total, Group C	651	25	26
Total Manufacturing	13,839	264	52
Non-Manufacturing	359	18	20
Total, Industry	14,198	282	50

*Includes allowance for depreciation

Table 13

Comparison of Current Intra-mural Research & Development Expenditures by Manufacturing Industries in Canada and the United States, 1965, as a Percentage of Total Value Added.

Sources

(a) For Canada: D.B.S.

(b) For the United States: National Science Foundation, *Reviews of Data on Science Resources*, NSF 66-33, No. 10, Washington, December 1966.

Commentary

The table compares research and development by manufacturing industry in Canada and the United States in terms of current intra-mural expenditures on R & D expressed as a percentage of total value added by manufacturing and non-manufacturing activities*. This ratio is sometimes called "research intensity".

The United States has a higher research intensity in every industry except Paper and Primary Metals. In comparison with Canadian industry, U.S. industry spends 6.1 times as much on R & D in the Transportation Equipment Industry, 4.8 times as much in the Non-Metallic Products Industry, and 4.6 times as much in the Machinery Industry, relative to net output in terms of total value added.

*Value of total operational revenue less total cost of materials, supplies, fuel and electricity used and goods purchased for re-sale, all adjusted for inventory changes where required.

Table 13

Comparison of Current Intra-mural Research & Development Expenditures by Manufacturing Industries in Canada and the United States as a Percentage of Total Value Added

MANUFACTURING INDUSTRY	CURRENT R & D EXPENDITURES % VALUE ADDED		
	UNITED STATES*	CANADA	RATIO: $\frac{\text{U.S.}}{\text{CAN.}}$
Manufacturing:			
Group A			
Machinery	4.94	1.07	4.6
Transportation Equip.	21.29	3.49	6.1
Electrical Products	15.66	5.21	3.0
Chemicals	6.98	2.70	2.6
Petroleum.....	10.47	4.08	2.6
Total, Group A	12.88	3.36	3.8
Group B			
Rubber	2.93	0.99	3.0
Paper	0.90	1.05	0.9
Primary Metals	1.15	1.18	—
Metal Products	1.02	0.27	3.8
Non-metallic Products	1.50	0.31	4.8
Total, Group B	1.31	0.79	1.7
Group C			
Food	0.64	0.24	2.7
Wood and Furniture.....	0.16	0.04	4.0
Other Manufacturing	1.72	0.56	3.1
Total, Group C	0.88	0.35	2.5
Total Manufacturing	6.16	1.42	4.3

*Includes allowance for depreciation

Chart 15

Current Intra-mural Research & Development Expenditures by Canadian Manufacturing Industries, 1965, as a Percentage of Total Value Added, showing Source of Funds.

Source

D.B.S.

Commentary

The chart compares research and development by Canadian manufacturing industries in terms of current intra-mural R & D expenditures expressed as a percentage of total value added, that is, "research intensity".

The Electrical Products Industry at 5.21% has the highest research intensity. The Petroleum Industry ranks second, Transportation Equipment third, and Chemicals fourth. The Wood and Furniture Industry is last with a research intensity of 0.04.

Chart 15

Current Intra-mural Research & Development Expenditures by Canadian Manufacturing Industries, 1965

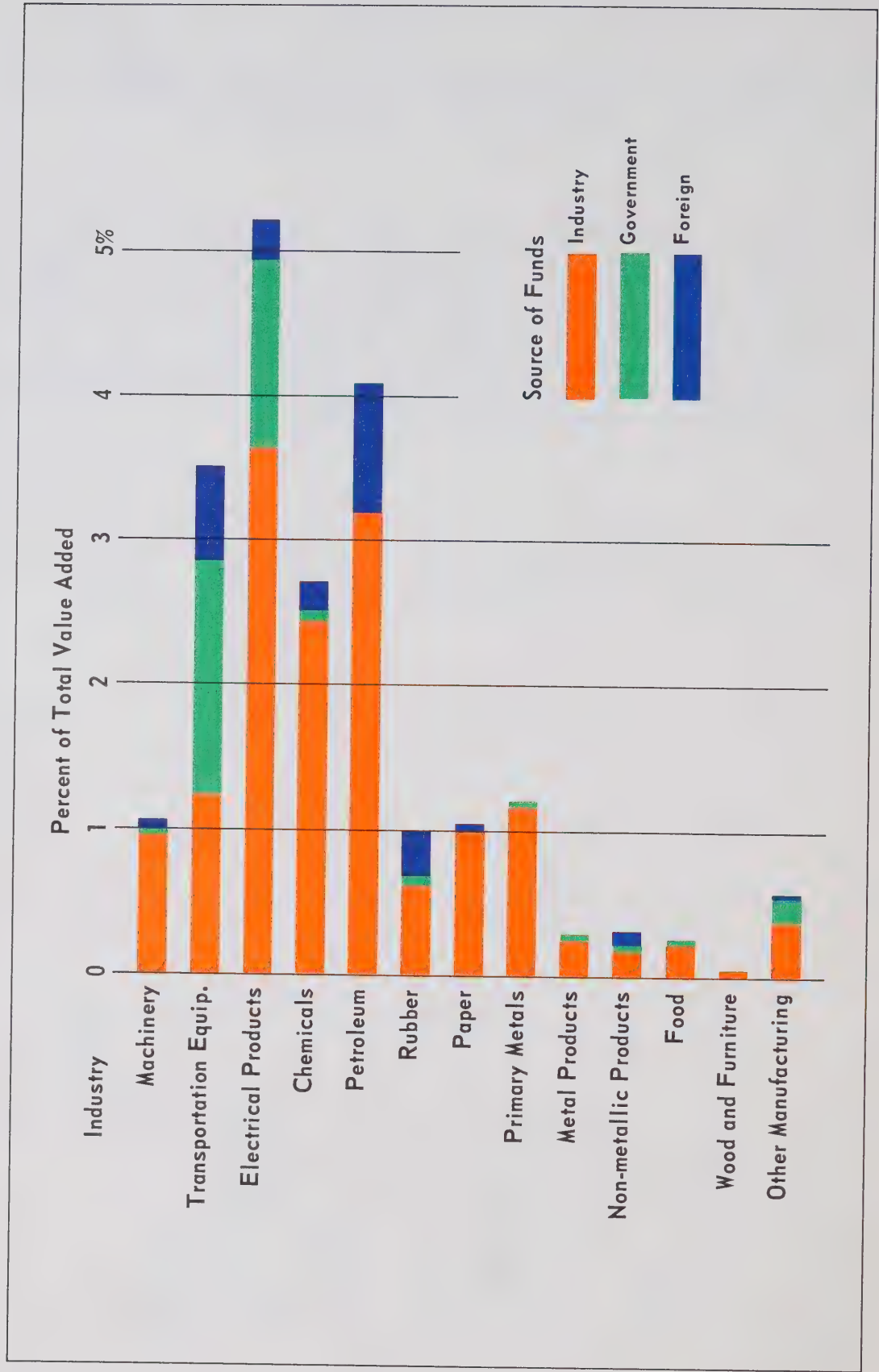


Table 14 and Chart 16

Canadian Federal Government Expenditures in Industry for Research and Development, 1959-60 to 1965-66.

Source

D.B.S. and Public Accounts.

Commentary

The table and chart show how Federal Government expenditures in industry for research and development have varied over the years from 1959-60 to 1965-66 in the following categories:

1. Research and Development Contracts:

- (a) Department of National Defence, including the Defence Research Board.
- (b) Other Government Departments and Agencies.

2. Industrial Research and Development Assistance Programs:

- (a) Industrial Research Assistance Program (I.R.A.P.) established in 1961, and administered by the National Research Council.
- (b) Program for the Advancement of Industrial Technology (P.A.I.T.) established in 1965, and administered by the Department of Industry.
- (c) Defence Industrial Research Program (D.I.R.) established in 1961 and administered by the Defence Research Board of the Department of National Defence.
- (d) Defence Development Sharing Program (D.D.S.P.) established in 1959, and administered by the Department of Industry.

Expenditures under National Defence contracts dropped from \$15.4 million in 1959-60 to a low of \$5.8 million in the austerity year of 1962-63, then increased to \$29.1 million in 1965-66. With the exception of 1962-63, expenditures made under contracts placed with industry by other Federal Government Departments and Agencies increased steadily from \$3.0 million in 1959-60 to \$7.4 million in 1965-66. Among these other Departments and Agencies, Atomic Energy of Canada Limited has been the largest spender, accounting for \$5.3 million, more than 72% of the total for the group, in fiscal year 1965-66.

Expenditures made under the Industrial Research and Development Assistance Programs have increased substantially since 1959 and in 1965-66 accounted for over 47% of all Federal Government expenditures in industry for R & D. While the Defence Development Sharing Program, which was the first assistance program to be established, accounted for a very large proportion (73%) of the total expenditures under these programs in 1965-66, expenditures under the Program for the Advancement of Industrial Technology are expected to exceed them in a few years.

Table 14

Canadian Federal Government Expenditures in Industry for Research & Development, 1959-60 to 1965-66

	FISCAL YEAR						
	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66
	— \$ MILLIONS —						
Research & Development Contracts:							
Department of National Defence	15.4	10.2	9.4	5.8	8.6	13.4	29.1
Other Departments and Agencies.....	3.0	4.5	5.9	4.7	5.1	5.5	7.4
Total, R & D Contracts.....	18.4	14.7	15.3	10.5	13.7	18.9	36.5
Industrial R & D Assistance Programs:							
Industrial Research Assistance Program (I.R.A.P.).....	—	—	—	0.5	1.6	2.2	3.3
Program for the Advancement of Industrial Technology (P.A.I.T.).....	—	—	—	—	—	—	0.4
Defence Industrial Research Program (D.I.R.).....	—	—	—	1.2	2.6	3.8	5.3
Defence Development Sharing Program (D.D.S.P.)	1.8	2.9	4.4	8.0	19.0	20.5	23.9
Total, R & D Assistance Programs.....	1.8	2.9	4.4	9.7	23.2	26.5	32.9
Total Expenditures in Industry	20.2	17.6	19.7	20.2	36.9	45.4	69.4

Chart 16

Canadian Federal Government Expenditures in Industry for Research & Development, 1959-60 to 1965-66

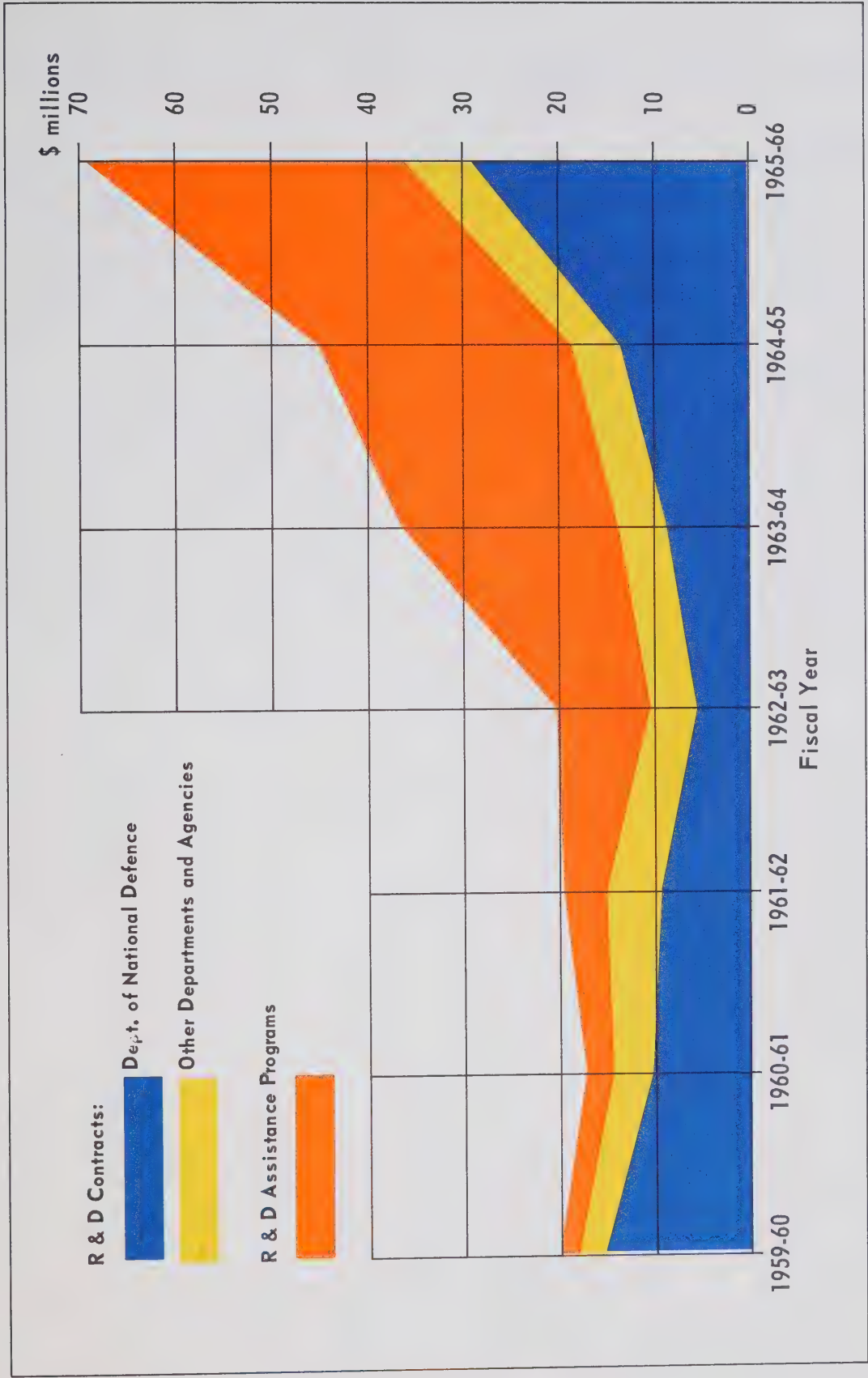


Table 15

Canadian Federal Government Programs to Assist Industrial Research & Development.

Source

- (a) For Industrial Research Assistance Program (I.R.A.P.): National Research Council.
- (b) For Program for the Advancement of Industrial Technology (P.A.I.T.): Department of Industry.
- (c) For Defence Industrial Research Program (D.I.R.): Defence Research Board.
- (d) For Defence Development Sharing Program (D.D.S.P.): Department of Industry.

Commentary

Two hundred and thirteen Canadian firms have received \$117.4 million from the Federal Government to assist them in undertaking 497 research and development projects, estimated to cost in total about \$335 million. Eighty-four firms have received assistance for two or more projects, and 41 of these firms have received assistance under more than one of the four government programs.

As might be expected, the two development programs (i.e., P.A.I.T. and D.D.S.P.) have supported relatively fewer but more expensive projects than the two research programs (i.e., I.R.A.P. and D.I.R.). Average estimated total cost of projects supported under each of the four programs is as follows:

Program	Average Estimated Total Project Cost \$ thousands
I.R.A.P.	279
P.A.I.T.	388
D.I.R.	322
D.D.S.P.	2010

Table 15

Canadian Federal Government Programs to Assist Industrial Research & Development

PROGRAM	NUMBER OF FIRMS	NUMBER OF PROJECTS	FED. GOVT. EXPENDITURES	TOTAL FED. GOVT. EXPENDITURES & COMMITMENTS	EST. TOTAL COST OF PROJECTS
				- \$ MILLIONS -	
Industrial Research Assistance Program (I.R.A.P.) ⁽¹⁾	103	178	7.6	12.8 ⁽⁶⁾	49.6 ⁽⁷⁾
Program for the Advancement of Industrial Technology (P.A.I.T.) ⁽²⁾	59	65	3.0	13.5	25.2
Defence Industrial Research Program (D.I.R.) ⁽³⁾	58	148	15.2	24.2	47.6
Defence Development Sharing Program (D.D.S.P.) ⁽⁴⁾	52	106	91.6	110.6	213.1
Total	213 ⁽⁵⁾	497	117.4	161.1	335.5

(1) Cumulative totals as of March 31, 1966.

(2) Cumulative totals as of December 31, 1966.

(3) Cumulative totals as of November 15, 1966.

(4) Cumulative totals as of December 31, 1966.

(5) 41 firms have received assistance under more than one program.

(6) Includes expenditures to March 31, 1966 and grants for fiscal year 1966-67 only.

(7) Estimated total cost of all I.R.A.P. projects (active and inactive) as of October 1, 1966.

Table 16

Canadian Federal Government Tax Incentive for Scientific Research.

Source

Department of National Revenue.

Commentary

The Federal Income Tax Act allows a taxpayer to deduct from income all his current expenditures for scientific research and all his capital expenditures (for the acquisition of property other than land) for scientific research in the year in which they are incurred. In 1962, a special incentive was introduced which permitted a corporation to deduct an additional allowance equal to 50 percent of the increase in its expenditures in Canada for scientific research over those in the last taxation year of the corporation ending before April 11, 1962 (i.e. 1961 base year). This incentive was applicable in each taxation year from 1962 to 1966 inclusive. On March 10, 1967 it was replaced by the Industrial Research and Development Incentives Act.

For the taxation year 1964, the latest year for which data is available, it will be seen that 397 corporations declaring a total taxable income of \$993.3 million claimed research expenditures amounting to \$133.7 million of which they claimed \$82.4 million was eligible for the additional allowance for scientific research. In other words, 397 corporations claimed to have increased their expenditures in Canada on scientific research from \$51.3 million in 1961 by \$82.4 million to \$133.7 million in 1963 or about 38% per annum.

Table 16

Canadian Federal Income Tax Incentive for Scientific Research

	TAXATION YEAR		
	1962	1963	1964
Number of claimants.....	104	265	397
Total taxable income — \$ millions	460.7	890.3	993.3
Total R & D expenditures — \$millions.....	49.9	99.9	133.7
R & D expenditures in excess of expenditures in 1961 base year — \$ millions	12.4	52.4	82.4
Number of claimants with no taxable income	n.a.	44	95
Estimated tax loss — \$ millions.....	3.0	8.1	12.8

GLOSSARY

Research and Development

Applied Research

Work undertaken primarily for the advancement of scientific knowledge but with a specific practical aim in view.

Basic Research

Work undertaken primarily for the advancement of scientific knowledge, without a specific practical application in view.

Development

The use of the results of fundamental and applied research directed to the introduction of useful materials, devices, products, systems, and processes, or the improvement of existing ones.

Research and Development Activities

The guiding line to distinguish R and D activity from non-research activity is the presence or absence of an element of novelty or innovation. Insofar as the activity follows an established routine pattern it is not R and D. Insofar as it departs from routine and breaks new ground, it qualifies as R and D.

If the primary objective is to make further improvements on the product or process, then the work comes within the definition of R and D. If, on the other hand, the product or process is substantially "set" and the primary objective is to develop markets or to do pre-production planning, or to get the production process going smoothly then the work is no longer R and D.

Sectors

Foreign

Foreign sources of funds include all foreign bodies outside national territory and any international organizations within national territory.

Foreign extra-mural expenditures include expenditures for research and development performed outside national territory as well as payments made to international organizations on national territory, but do not include expenditures made outside national territory which are an integral part of the national research and development effort.

Government

The function of Government is to organize for, but not normally to sell to, the community those common services which cannot otherwise be conveniently and economically provided, and to act as the administrative agency for the economic and social policy of the community. This sector includes central and local government agencies which undertake such activities as administration, defence and health services irrespective of their treatment in the government budget. Atomic Energy of Canada Limited and the Provincial Research Councils and Foundations are included in this sector.

Higher Education

The higher education sector includes all universities, colleges of technology and other institutes of higher education, whatever their sources of finance or legal status. It includes also institutes exclusively engaged in research, which are attached to or under the general supervision of institutes of higher education and their subsidiary or affiliated bodies such as experimental stations and clinics.

Industry

The Industry sector includes all firms, organizations and institutions which produce goods and services for sale to the general public at a price intended approximately to cover the cost of production, and the non-profit institutions serving them. Industrial research associations, commercial research institutes or consultants, nationalised industries, public utilities, transport undertakings, communications and broadcasting, and all other government business enterprises such as Polymer Corporation Limited, Canadian National Railways, Air Canada, etc., are included within this sector.

Private Non-Profit

The private non-profit sector includes all private organizations, which are not established primarily with the aim of earning a profit, and are not mainly rendering services to enterprises. Hospitals, voluntary health organizations, scientific and technical societies, foundations and private individuals are included in this sector.

Sector of Performance

Sector in which the R & D activities are undertaken, regardless of by whom they are financed.

Source of Funds

The sector which provides the funds to support R and D regardless of the sector in which the activities are undertaken:

Expenditures

Capital Expenditures

Capital expenditures include all major items of equipment, apparatus, plant and pilot plant, and all new buildings and major renovations or alterations to existing buildings, but do not include allowances for depreciation.

Current Expenditures

Current expenditures include salaries, wages and related costs, such as fringe benefits, of all research and development personnel (including all classes of supporting personnel), materials and supplies, water and fuel, maintenance and repair of buildings and equipment, administrative expenses and a share of overhead expenses, but do not include allowances for depreciation (except where otherwise noted).

Extra-mural Expenditures

Extra-mural expenditures include all funds spent for R & D performed outside a particular organization or sector of the economy.

Gross National Expenditures on R & D

The sum of the intra-mural expenditures of the four sectors gives the amount of R & D performed within the country, excluding the activities of international organizations in national territory but including any activities which are an integral part of the nation's R & D effort undertaken outside national territory.

Intra-mural Expenditures

Intra-mural expenditures include all funds used for the performance of R & D within a particular organization or sector of the economy, regardless of the source of funds.

Industrial Classifications

Chemicals

Companies primarily engaged in manufacturing industrial chemicals, medicinal and pharmaceutical preparations, soaps and washing compounds, paints and varnishes, and miscellaneous chemicals including fertilizers, sweeping compounds, adhesives, polishes and dressings.

Electrical Products

Companies primarily engaged in the manufacture of electrical machinery and appliances, communication equipment, and other electrical products such as electric wires, batteries, fixtures, computers and data processors.

Food

Companies primarily engaged in processing foods and beverages for consumption.

Machinery

Companies primarily engaged in manufacturing agricultural implements, commercial refrigeration and air conditioning equipment, office and store machinery, and machinery and equipment used for construction, mining, processing and manufacturing.

Metal Products

Companies primarily engaged in fabricating structural steels; in stamping, pressing and coating sheet metal; in manufacturing ornamental metal products, wire and wire products, hardware, tools and cutlery, and heating equipment. Machine shops, boiler and plate works are also included.

Non-manufacturing

Non-manufacturing includes mines, quarries and oil wells, the construction industry, transportation, storage, communications and other utilities, scientific and engineering services.

Non-metallic Products

Companies primarily engaged in the manufacture of articles made entirely or mainly of non-metallic minerals such as cement, asbestos, clay, glass, stone and concrete, or in the preparation of such materials.

Other Manufacturing

Other manufacturing includes clothing and knitting mills, leather products, tobacco products, textiles, and miscellaneous manufacturing industries.

Paper

Companies primarily engaged in the manufacture of pulp either from wood or other fibres, conversion of these pulps into any kind of paper board, or the manufacture of paper and paper board into converted products.

Petroleum

Companies primarily engaged in refining crude petroleum, and in manufacturing petroleum and coal products.

Primary Metals

Includes iron and steel mills, steel pipe and tube mills, iron foundries, and companies primarily engaged in smelting and refining ores, or in rolling, casting and extruding metals.

Rubber

Companies primarily engaged in manufacturing all kinds of natural or synthetic rubber products.

Transportation Equipment

Companies primarily engaged in manufacturing or assembling aircraft and parts, motor vehicles, railroad rolling stock, ships and boats, or in the repair of all of the above items except motor vehicles.

Wood and Furniture

Companies primarily engaged in producing lumber and wood basic materials, and manufacturing finished articles made entirely or mainly of wood, and companies primarily engaged in the manufacture of furniture and fixtures for the household, office or school, regardless of the materials used.

Economic Terms

Gross National Product

Gross National Product (G.N.P.) for a given period of time is the total value of all final goods and services produced by a nation's economy in that period before deduction of depreciation charges and other allowances for business and institutional consumption of durable capital goods.

Total Value Added

Total value added by manufacturing and non-manufacturing activities for a given period of time is the value of total operational revenue less the total cost of materials, fuel and electricity used and goods purchased for re-sale in that period, all adjusted for inventory changes where required.

APPENDIX

Tables A, B, C & D

Current and Capital Expenditures on Research & Development in Canada, 1965, by Sector of Performance and by Source of Funds, and by Type of Research-Development Activity.

Sources

- (a) For R & D performed by the government sector: D.B.S., *Federal Government Expenditures on Scientific Activities, Fiscal Year 1964-65*. Catalogue No. 13-401, February, 1967; and D.B.S. unpublished preliminary results of a survey of research and development expenditures of Provincial Research Councils and Foundations, 1963-66.
- (b) For R & D performed by the industry sector: D.B.S. unpublished preliminary results of a survey of industrial research and development expenditures in Canada, 1965.
- (c) For R & D performed by the higher education sector: Estimates prepared by G.T. McColm, Science Secretariat and based on data from N.R.C., *Expenditures on Research in Science and Engineering at Canadian Universities*, Report of a Survey for the Forecasting Committee of the National Research Council, Office of Economic Studies ESI, NRC No. 9196, September, 1966. Distribution by type of research-development activity (Table D) has been estimated by the Department of Industry.
- (d) For R & D performed by the private non-profit sector: D.B.S., *Expenditures on Scientific Activities by Non-profit Organizations*, 1965, D.B.S. Catalogue 13-526, January, 1967. Distribution by type of research-development activity (Table D) has been estimated by the Department of Industry.

Table A

Current Expenditures for Research & Development in Canada, 1965, by Sector of Performance and by Source of Funds

SOURCE OF FUNDS	SECTOR OF PERFORMANCE				
	GOVERNMENT	INDUSTRY	HIGHER EDUCATION	PRIVATE NON-PROFIT	TOTAL
			- \$ MILLIONS -		
Government	186.6	49.9	40.0	2.2	278.7
Industry	1.4	158.7	3.0	0.1	163.2
Higher Education	-	-	44.0	-	44.0
Private Non-profit.....	0.2	-	8.0	3.7	11.9
Foreign.....	0.3	25.5	5.0	0.7	31.5
Total.....	188.5	234.1	100.0	6.7	529.3

Table B

Capital Expenditures for Research & Development in Canada, 1965, by Sector of Performance and by Source of Funds

SOURCE OF FUNDS	SECTOR OF PERFORMANCE				
	GOVERNMENT	INDUSTRY	HIGHER EDUCATION	PRIVATE NON-PROFIT	TOTAL
	- \$ MILLIONS -				
Government.....	54.9	-	17.0	0.4	72.3
Industry.....	-	49.8	-	-	49.8
Higher Education.....	-	-	27.0	-	27.0
Private Non-profit.....	0.5	-	1.0	0.7	2.2
Foreign.....	-	-	1.0	0.1	1.1
Total.....	55.4	49.8	46.0	1.2	152.4

Table C

Current and Capital Expenditures for Research & Development in Canada, 1965, by Sector of Performance and by Source of Funds

SOURCE OF FUNDS	SECTOR OF PERFORMANCE				
	GOVERNMENT	INDUSTRY	HIGHER EDUCATION	PRIVATE NON-PROFIT	TOTAL
			- \$ MILLIONS -		
Government	241.5	49.9	57.0	2.6	351.0
Industry	1.4	208.5	3.0	0.1	213.0
Higher Education	-	-	71.0	-	71.0
Private Non-profit	0.7	-	9.0	4.4	14.1
Foreign	0.3	25.5	6.0	0.8	32.6
Total	243.9	283.9	146.0	7.9	681.7

Table D

Current Expenditures for Research & Development in Canada, 1965, by Sector of Performance and by Type of Research—
Development Activity

SECTOR OF PERFORMANCE	BASIC RESEARCH	APPLIED RESEARCH	DEVELOPMENT	TOTAL
	— \$ MILLIONS —			
Government	37.8	121.2	29.5	188.5
Industry	8.9	65.0	160.2	234.1
Higher Education	70.0	25.0	5.0	100.0
Private Non-profit	1.7	4.3	0.7	6.7
Total	118.4	215.5	195.4	529.3

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